

Metal Recovery from Electronic Scrap by Leaching and Electrowinning

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An aqueous leaching and electrowinning process (Fig. 1) is being developed for recovering Au, Pd, Ag, Cu, Sn, Pb etc. from electronic scrap (1).

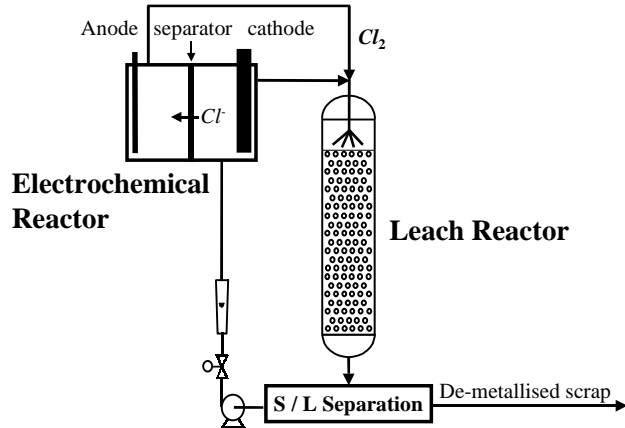
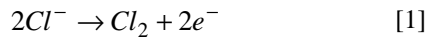
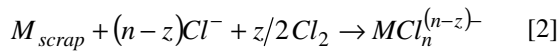


Fig. 1. Leach - electrowin process for recovering metals from electronic scrap.

In an electrochemical reactor, chlorine is generated at a Ti / RuO₂ anode in acidic aqueous chloride electrolyte:



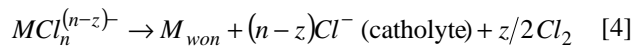
This is used in a leach reactor to drive the oxidative dissolution of those metals from electronic scrap, shredded to < 4 mm:



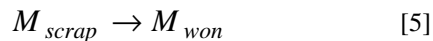
The metals are recovered from solution by electrodeposition at a graphite felt cathode as the counter reaction for the anodic generation of chlorine:



Hence, the overall reaction in the electrochemical reactors is:



However, the overall process involves inputting electrical energy to move the metals from scrap to cathode and produces only a de-metallised waste, the net chemical change being the sum of reactions [2] and [4]:



Using gold as an example, the thermodynamics of such a metal-chlorine-water system are summarised in Fig. 2, which predicts a driving force of *ca.* 0.5 V for reaction [2] over the pH range of about 0 – 8. However, the presence of other metals, especially tin in soldered joints, required electrolytes with hydrochloric acid concentrations > 1 M

to solubilise Sn(IV) (2), in what was designed to be a non-selective metal dissolution process. Such low pHs are also desirable for kinetic reasons, as the reduction kinetics of ‘active chlorine’ (i.e. Cl₂ + HOCl + ClO⁻) on gold decrease with increasing pH (3). However, such acid conditions place severe constraints on the choice of construction materials for the reactor system; in the laboratory, glass was the primary construction material.

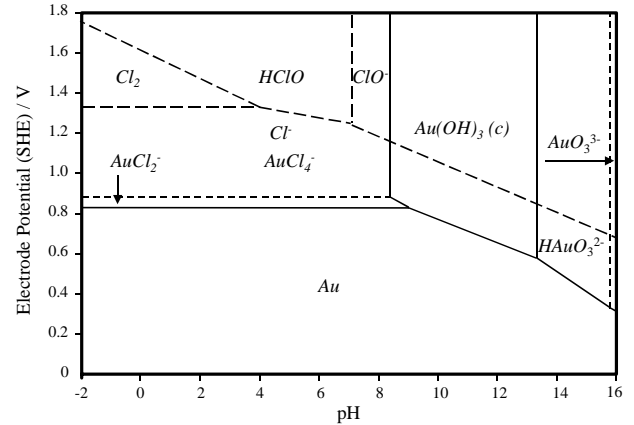


Fig. 2. Potential-pH diagram for the Au-Cl-H₂O system at 298 K and AuCl_n⁻ activity = 10⁻³, Cl⁻ activity = 5; 298 K, 0.1 MPa.

The feasibility of depleting dissolved gold concentrations to below analytically detectable levels in chloride electrolytes has been reported previously (4). However, control of the cathode potential will be shown to enable selective recovery of different metals, if that is desirable. Alternatively, non-selective recovery can be achieved by operating the cathode at suitably low potentials. This could be followed by electrorefining the metal deposit.

The primary loss in cathode current efficiency arises from dissolved chlorine being returned from the leach reactor and reduced at the catholyte, rather than on the metal scrap. This is minimised by an electrolyte recycle loop, not shown in Fig. 1, for the leach reactor, to minimise the dissolved chlorine concentration. Similarly, another recycle loop is used for the cathode, to enable mass transport rates to be controlled independently of efflux metal concentration from the cathode. Means of measuring the dissolved chlorine concentrations on-line will be presented.

REFERENCES

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4. G.H. Kelsall and M.A.Diaz, International Patent WO 87/06274 (16.04.87).